

500th Birthday of Andreas Vesalius, the Founder of Modern Anatomy

"Vivitur Ingenio, Caetera Mortis Erunt" ("Genius Lives On, All Else Is Mortal")

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Abstract: It is often said that regional anesthesia is the practice of applied anatomy. Therefore, it is fitting that on the occasion of his 500th birthday, we celebrate the life and work of the brilliant Flemish anatomist, Andreas Vesalius (1514–1564), the founder of modern anatomy.

(Reg Anesth Pain Med 2014;39: 450–445)

The subspecialties regional anesthesia and pain medicine embody what has been called the "practice of applied anatomy." Therefore, it is fitting in this journal to celebrate the life and work of the brilliant anatomist, Andreas Vesalius, the founder of modern anatomy, on his 500th birthday (Fig. 1). Some historians argue that he influenced the thinking of his contemporaries to such an extent that our understanding of anatomy can be divided into pre- and post-Vesalius eras.

The authors had opportunity to collaborate with the Catholic University at Leuven and the Andreas Vesalius Institute of Anatomy to research Vesalius and consequently were granted access to some of the well-known historians of Vesalius in his home country Brabant, now Belgium. By all accounts, Vesalius was extraordinary and made contributions to medicine that prevail, despite his brushes with the law. Given the importance of anatomy to *Regional Anesthesia and Pain Medicine*, we desire to highlight the life and work of Andreas Vesalius for the journal's readership. As Vesalius' works are vast, scholars of Vesalius are encouraged to consult the list of Vesaliana in the Harvey Cushing second edition (1962) of Vesalius' bibliography and the most recent Vesaliana (2014) by Maurits Biesbrouck.¹

EARLY LIFE

Andreas Vesalius was born on New Year's Eve 1514 in Brussels, Brabant, into a wealthy family of physicians and pharmacists.² His father was employed as an apothecary (modern-day pharmacist) by Emperor Charles V. As with other prominent men of the Renaissance, Vesalius was born in an era of great intellectual discourse.

His early education at the Castle School of the University of Louvain included instruction in rhetoric, philosophy, logic, and

classical languages (Latin, Greek, and Hebrew).³ Shortly thereafter, his interest turned to medicine, and he went to Paris to study anatomy. When Charles V declared war on France 3 years later, in 1536, Vesalius returned to the University of Louvain to finish his studies in medicine, receiving the degree of licentiate (equivalent to a master's degree). He presented a thesis titled "Paraphrasis in nonum librum Rhaze" (Leuven, Rutgerus Rescuis, 1537), a paraphrase of the ninth book of Rhazae about the Arabic pharmacology.⁴ He was not pleased with the printing and published it again a month later in Basel. Thereafter, Vesalius moved to the capital of the scientific Renaissance, Padua, Italy, to pursue his passion for medicine and anatomy. By December 1537, he received his doctorate of medicine and was nominated as a professor. He worked there as a professor of surgery and anatomy, succeeding Paolo Colombo from Cremona.⁵

Vesalius signed his publications (letters) as Andreas Vesalius Bruxellensis (meaning from Brussels). Bruxella (Brussels) was the capital of Brabant, then part of the Habsburg Netherlands, and belonging to the Holy Roman Empire, with Charles V as emperor.

ANATOMY BEFORE VESALIUS

The dissection of corpses parallels human history. Egyptian mummification included body dissection and organ removal for preservation. Although the ancient Greeks dissected human bodies and considered the dissections as an "extension of the science,"⁶ this was prohibited by many societies before the Renaissance, particularly those influenced by the Roman Catholic Church. The Church controlled research and exploration for many centuries and maintained that dissecting a dead body would destroy its ability to be resurrected in the afterlife.

Furthermore, the primary objective in the pursuit of scientific truth was to support established theories and teachers.⁵ Many early depictions of anatomy were by the Roman physician, surgeon, and philosopher in the Roman Empire Aelius Galenus, or Claudius Galenus, better known as Galen of Pergamon (born 129 AD), whose teaching came mostly from animals. His anatomical theories were standard text for medical students for more than 1300 years. Like Vesalius, Galenus aspired to break the boundaries of the science of the era, while his contemporaries held to accepted scientific principles.⁷

Unfortunately, Galen's anatomical writing occurred when systems of anatomical nomenclature did not exist, making it difficult to translate and understand all of his texts. Moreover, Galen did not have an effective method of knowledge dissemination because the printing press had not yet been invented. His manuscripts were hand copied, creating obstacles and errors in reproduction.⁸ As dissection of human bodies was considered blasphemous by the Roman Empire, Galen was limited to work on animal dissections, usually on the Barbary monkey. In a startling experiment in 1541, Vesalius put the skeleton of a monkey and the skeleton of a human, side by side. During his examination, he found a process of the lumbar

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Accepted for publication August 22, 2014.

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The authors declare no conflict of interest.

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ISSN: 1098-7339

DOI: 10.1097/AAP.0000000000000173

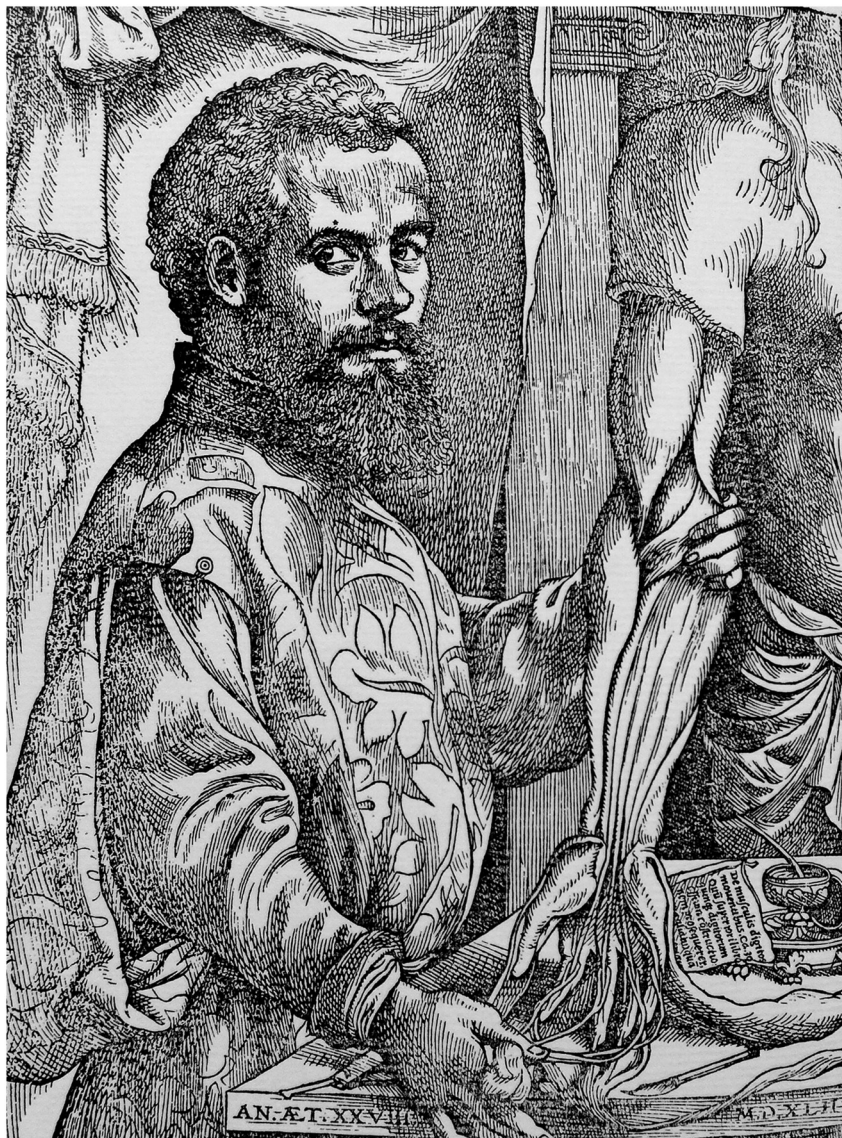


FIGURE 1. Andreas Vesalius (1514–1564).

vertebrae in the monkey that was not present in the human. Galen's teachings, however, had described the human vertebrae as having that process, and Vesalius suddenly realized that Galen had never performed a human dissection. He decried, "I cannot wonder enough at my stupidity and trust in Galen, which prevented me from seeing this before."⁹

ANATOMY DURING THE RENAISSANCE

The Renaissance ushered in a new era for the development of scientific medicine.¹⁰ The rules forbidding use of cadavers loosened when the Church deemed that the cadavers of prisoners were acceptable for scientific research.¹¹ This allowed Vesalius and his contemporaries an opportunity to dissect human bodies. During Vesalius' medical education, anatomy was required but was not valued as an essential subject.

In addition to the scientific advancements during the Renaissance, this era marked a shift in attention toward the human body as a subject of art. Artists including Leonardo da Vinci and Andrea

Mantegna inspired an aesthetic interest in the human body.¹² Ironically, these artistic depictions of human anatomy were confined to the art world and were not welcome in the medical arena.

The custom at that time was to learn about the human body by reading textbooks devoid of supporting images or illustrations; students rarely dissected corpses. Occasionally, the body of a dog, or more rarely, a human corpse, was brought into the lecture room. An uneducated barber clumsily dissected the body, whereas the doctor, who himself disdained the menial task of "hands-on" dissection, would read descriptions of the body from the accepted text.⁵ Any discrepancies between the text and the demonstrations would be disregarded by the professor on the pretext that changes in the human body occurred since the manuscript had been written.¹³ Furthermore, because there were no methods of preserving the body at the time, a complete dissection was almost impossible.

Vesalius readily voiced his disdain for such inconsistencies in learning. He wrote in his book, *Fabrica*, "For, except for 8 abdominal muscles shamefully mangled and in the wrong order, no other muscle or any bone, and much less an accurate series of

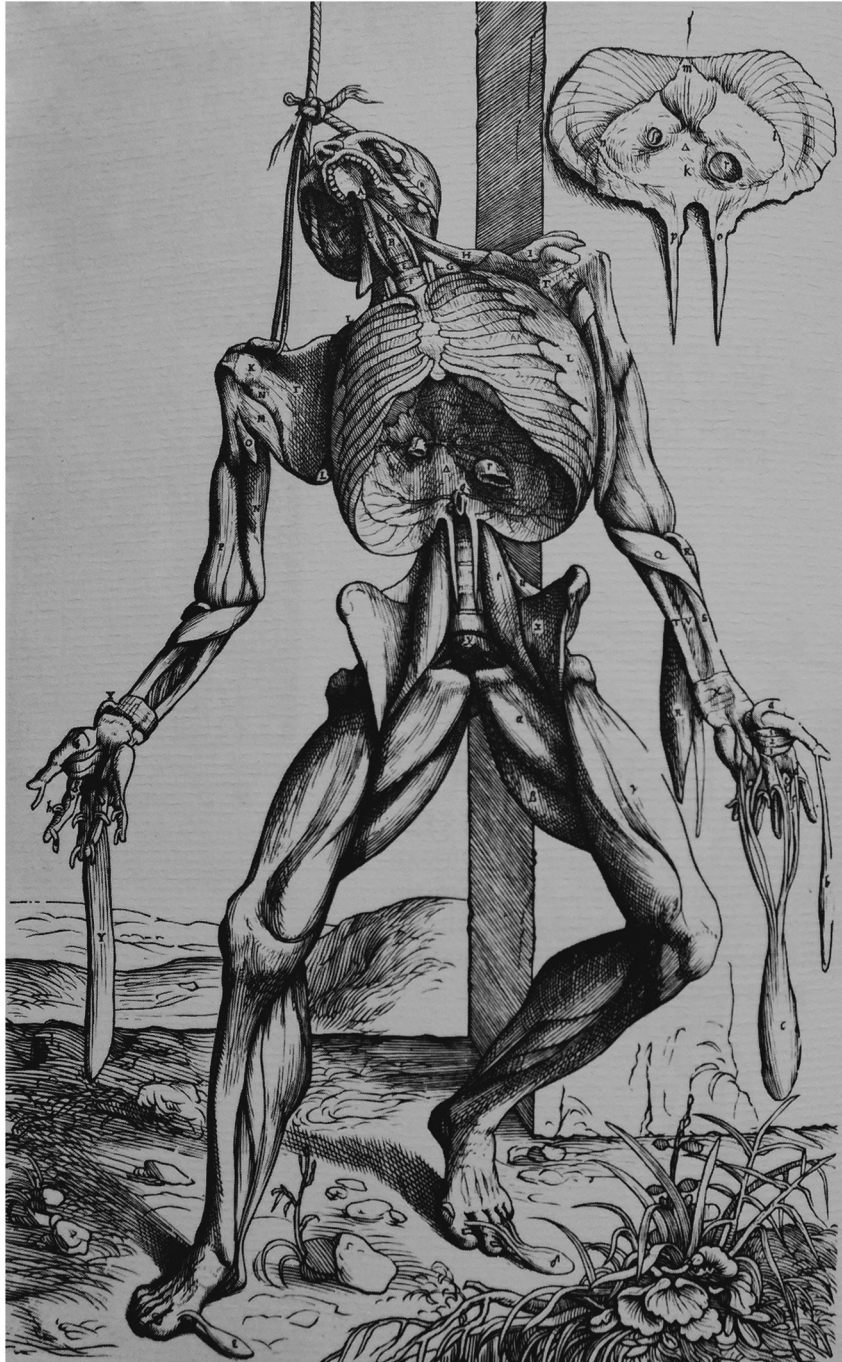


FIGURE 2. Depiction of labeled muscles in the *Fabrica*. Vesalius would fasten the cadaver in this manner to dissect and present “the muscle-man.” *De Fabrica*, seventh muscle dissection, page 190.

the nerves, veins, or arteries was ever demonstrated to me by anyone.”¹⁴ His radical views about hands-on learning stirred widespread change regarding the study of anatomy. Vesalius was considered “radical” and encountered considerable resistance from followers of Galen and older professors regarding studying or learning from pictures of the anatomy.

Undaunted, Vesalius proceeded to perform the dissections of the human body himself and depicted his findings in pictures. He wrote, “My study of anatomy would never have succeeded had I when working at medicine in Paris, been willing that the viscera

should be merely shown to me and my fellow students.... I had to put my own hand to the business.” With this mindset, Vesalius began studying anatomy, initially on the only part of the body that was freely accessible for study, the skeleton. In the 1500s, burials were often botched and incomplete, leaving bones scattered about cemeteries. Vesalius spent many hours studying these bones on the burial grounds of the Church of Innocents in Paris (now Les Buttes Chaumont). By moonlight, Vesalius and fellow students snuck onto the grounds to collect and study any scattered bones, risking being caught by the Church or attacked by hungry dogs,

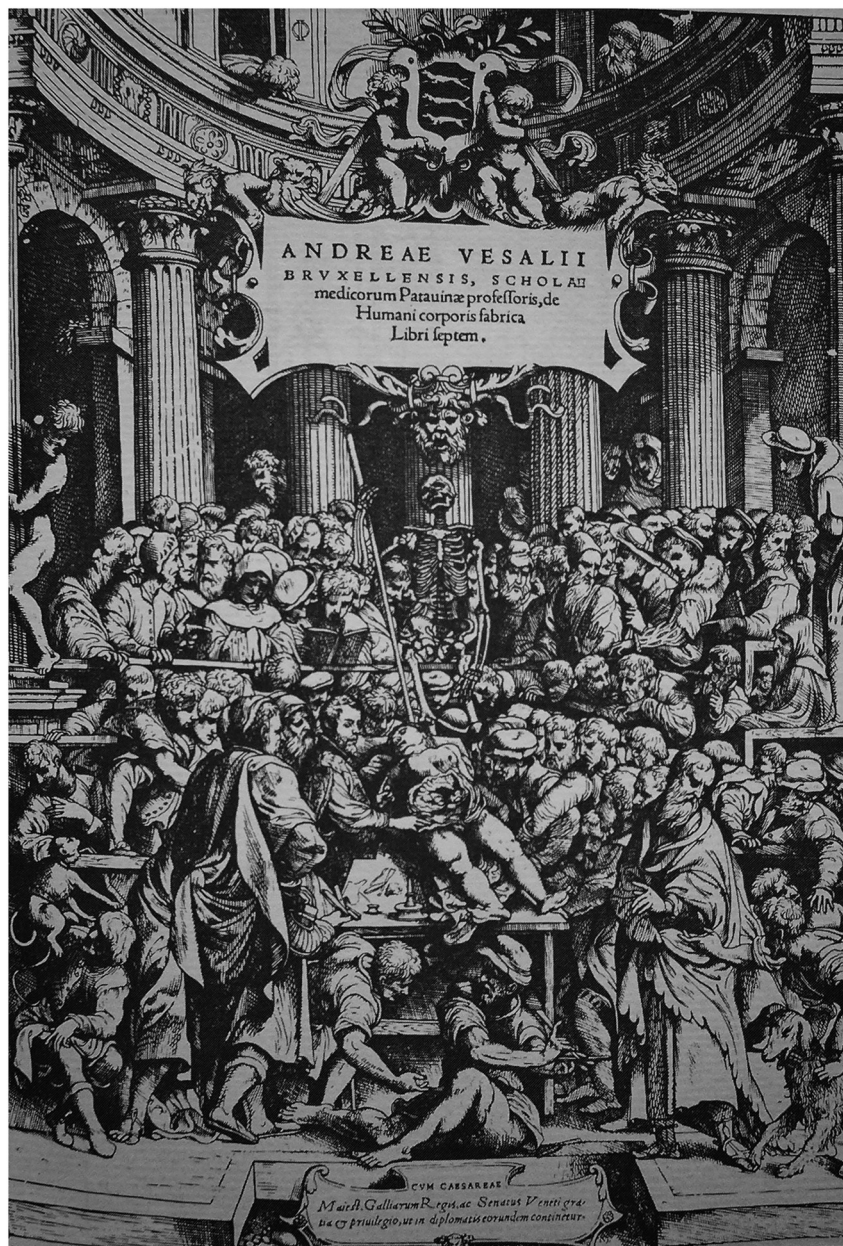


FIGURE 3. The title page of the *Fabrica* showing Vesalius conducting a dissection on a woman. Within arm's reach, there is a scalpel, a razor, a pen, an inkwell, a lighted candle, and a piece of paper. The barbers, who would have been performing the dissection, are practically under the table, which suggests Vesalius' new way of teaching that preferred professors dissecting with their own hands.

likewise seeking human remains.⁶ During a walk outside the city walls of Louvain, Vesalius came across a skeleton chained to a wooden stake. Guessing that the skeleton was that of a criminal who had been burned at the stake, and noting that it was dried and mostly intact, Vesalius decided to steal it. He smuggled the skeleton, piece by piece over the next few days, and then reassembled it at home.⁶ During his time in medical school, Vesalius became so adept at the study of anatomy that his fellow students and teachers soon asked him to conduct the dissections instead of the barbers.⁷

The Fabrica

Through his own anatomical dissections, it soon became clear to Vesalius that Galen's anatomy was often wrong.¹⁵

Although Vesalius was a dedicated follower of Galen and tried to believe Galen's teachings, his own observations forced him to reconsider old teaching and his own conceptions based on them. Hence, Vesalius broke away from outdated teachings and introduced new methods and principles for studying anatomy.⁵ Of note, Vesalius was one of the first to prepare and use anatomical charts in his early teaching of anatomy at Padua. His observations eventually led to the publication of 6 anatomical tables, the *Tabulae Sex*, in 1538. This first known hand-drawn anatomical work was widely replicated via use of the printing press.⁸

The year 1543 was an important year for science. In the same year that Copernicus published *De Revolutionibus*, in which he claimed that Earth is not at the center of the universe,¹⁶ Vesalius published his dissections and sketches in the most influential text:

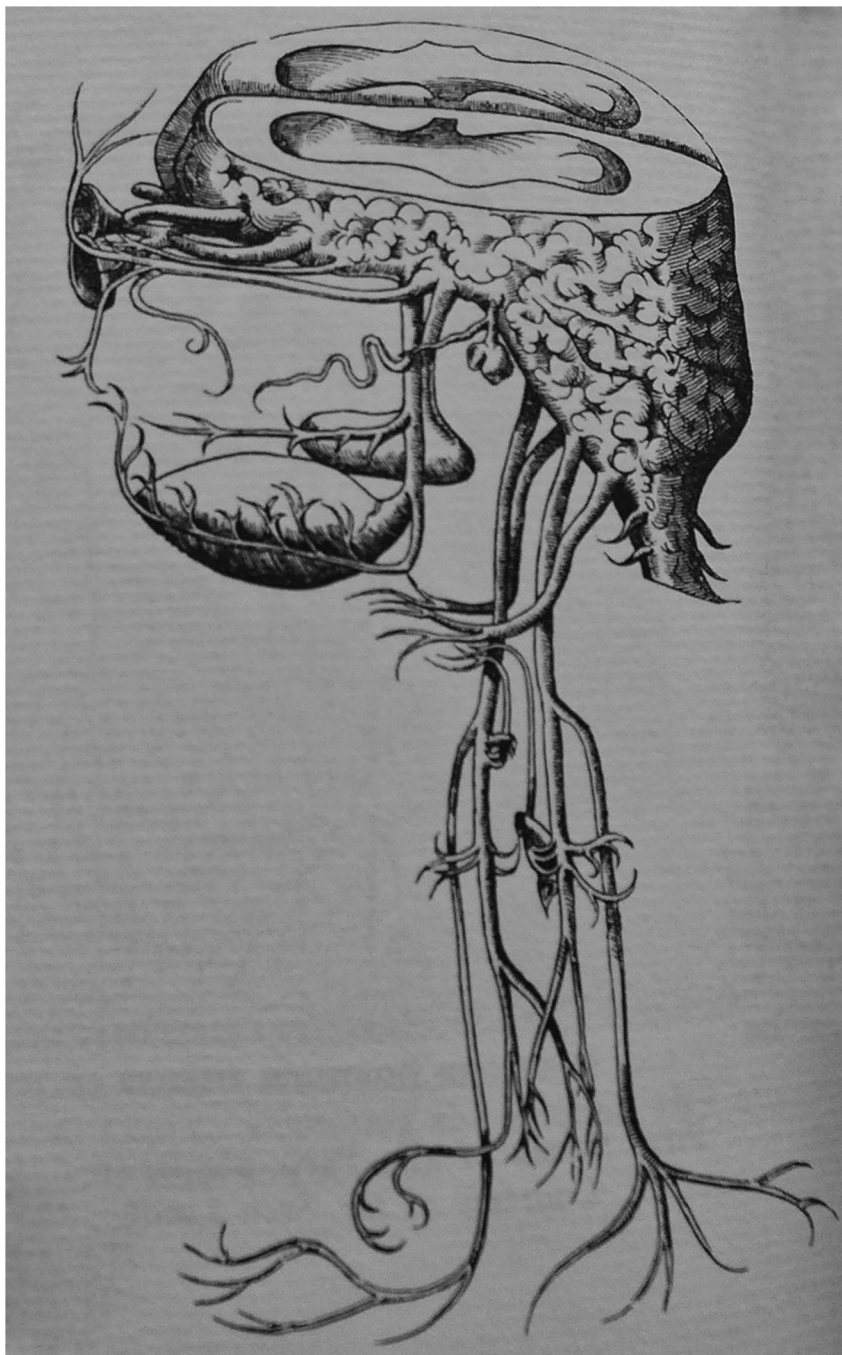


FIGURE 4. Vesalius's illustration of the cranial nerves. According to O'Malley,³ this picture was stolen by an unknown person and published in 1539 by Macrolius.

De Humani Corporis Fabrica Libri Septem (The Structure of the Human Body). This, Vesalius' 16th-century anatomical magnum opus, published in Latin in 1543 and 1555, is perhaps the most important book in the history of anatomy, with exquisite detail, insight, and imagery. The work consisted of 663 pages and contained some 420 separate illustrations. The pages of the *Fabrica* were cut in Venice on pear wood and transported with great care to Basel, Switzerland, for printing. These wood-carved printing blocks were carried by as many as 16 mules, over the Alps, to Basel. When printed, one *Fabrica* alone weighed 7 kg, was 7 cm thick,

and had a width and height of 62×43 cm. The beautiful woodcuts survived for more than 400 years, until most were destroyed in an Allied air raid of Munich in 1944. An incredibly high-quality, 2-volume annotated translation of the 1543 and 1545 editions of *De Humani Corporis Fabrica* has been published for this year's 500th anniversary celebration.¹⁷

The *Fabrica* had more influence on the evolution of anatomy and surgery than any previously published medical book.⁸ The *Fabrica* was replicated both quickly and accurately, widely distributed in Europe, and quickly adopted as the standard reference text

for anatomy. The *Fabrica* was also cleverly dedicated to the Holy Roman Emperor, Charles V, in the hopes of garnering favor and protection from the Emperor to dodge suspicions of heresy. The publication of *Fabrica* also helped Vesalius secure the position of Imperial Physician, in which he served until Charles V abdicated in 1556.

The *Fabrica* is widely held as the first great work of modern science, in part because of the vast number of illustrations with clear anatomical detail.⁹ Vesalius combined drawings with words and labeled bones and organs, which had not been done before (Fig. 2). He was also the first to describe the fine structure of nerves, veins, muscles, arteries, and the skeleton.¹⁸ Despite the prevailing Galenist attitude that anatomical illustrations hindered the study of anatomy, Vesalius understood the importance of illustrations and had professional artists complete the images for the *Fabrica* rather than attempting to do the drawings himself (Fig. 3).

The *Fabrica* is composed of seven books: Book I describes the bones; Book II, the muscles; Book III, the blood vessels; Book IV, the nervous system; Book V, the internal organs of the abdomen; Book VI, the heart and lungs; and Book VII, the brain.

ANDREAS VESALIUS AND THE NERVOUS SYSTEM

Vesalius is specifically credited as being the first to describe the nerves with great accuracy. In that regard, the *Fabrica* demonstrated the power of garnering scientific knowledge through example and observation.⁶ For example, in the era before Vesalius, nerves were thought to be hollow and “[carried] down animal spirit (the source of all motion and sensation) from the brain to produce animal faculty for the parts of the body.”¹⁴ Vesalius stated, “I can assert that I never found any passage of that sort even though I dissected the optic nerves of live dogs and other large animals for this purpose, and the head of a man as yet warm and scarcely a quarter hour after his decapitation. I inspected the nerves carefully, treating them with warm water, but I was unable to discover a passage of that sort in the whole course of the nerves. Nor was it at all apparent in the juncture of the nerves, even though it ought to have been apparent there if, according to Galen’s opinion, this is the reason the nerves are united.”¹⁴ Regarding the origin of nerves, he wrote, “Some consider the heart as the origin of the nerves, others the dural membrane which surrounds the brain... From dissection of the body, it is clear that no nerve arises from the heart as it seemed to Aristotle in particular and to no few others”¹⁴ (Fig. 4). His description of the plexus brachialis and the plexus ischiadicus is closely related to the modern views in these matters.

CONCLUSIONS

While we recognize Vesalius as an innovator, crucial to the development of modern medicine, many of his contemporary physicians in the low countries and France mocked and attacked his work. They disapproved of physicians performing dissections as this was work for common barbers. They also disapproved of Vesalius’ criticism of Galen’s teachings. The barrage of criticisms, lack of acceptance of his ideas, and ruthless pressure from peers must have immensely troubled Vesalius. The mounting criticism and opposition to the acceptance of this work led to an apparent crisis early in his career, where he on 1 occasion destroyed many of his unpublished manuscripts and swore he would never publish a book again.⁷

Sir Isaac Newton wrote, “If I have seen further, it is by standing upon the shoulders of giants.” Indeed, as anesthesiologists, we also stand on the shoulders of many great physician scientists such as Vesalius as we continue to explore human anatomy with ultrasound and other innovative and high-resolution imaging. His relentless quest for truth and efforts to teach others led to breakthroughs

in medicine. In this 500th anniversary celebration, we pay tribute to Andreas Vesalius for his courage to question dogma and to push the boundaries of the law, leaving us with his great discoveries in science and anatomy. Our increasing reliance on sophisticated imaging technologies, multidimensional modeling, and simulation for acquisition of skills necessary to practice medicine, learn anatomy, and perform regional blocks build upon the contributions of Vesalius. In keeping with advances in medicine, the modern-day Vesalius Institute has implemented a number of training programs for physicians in need of acquiring highly technical operative skills required to perform complicated surgical procedures, such as joint replacement, various laparoscopic surgeries, and modern methods of ultrasound-guided regional anesthesia and pain medicine procedures. Therefore, even 500 years after Vesalius, anatomy remains an essential science for the practices of medicine and surgery. Despite the widespread availability of multiple anatomical atlases, computer programs, and applications, there is still no replacement for hands-on dissection and training in cadavers.

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